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Applying Research in Forestry

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Using Sawdust as a Soil Amendment

Sawmills in Missouri produce approximately 760,000 tons of sawdust annually. While some sawdust is used for animal bedding, fuel pellets, charcoal and other products, much of it is stockpiled. Sawdust piles in the state are a source of organic matter that could be used to improve soils in home gardens, landscapes or crop fields.

Organic matter has many benefits in the soil. It improves drainage and aeration of the root zone and serves as a source of plant nutrients. It also holds moisture that is readily available to plant roots and serves to increase the availability of micronutrients such as iron and manganese. However, these benefits are attained only after the organic matter has decomposed and the lignin in the material is converted to humus.

While sawdust has been used as a soil amendment for centuries, it causes problems if used indiscriminately. The main problem is immobilization of nitrogen. Sawdust is composed of about 70% carbohydrates (cellulose and hemicellulose) and 27% lignin. Overall, it contains about 5O% carbon, 6% hydrogen, 44% oxygen and perhaps 0.1% nitrogen. When sawdust is incorporated into soil, the carbon provides a rich source of energy for bacteria and fungi that decompose it. However, the microbes also use nitrogen and can quickly deplete the entire supply of nitrogen available in the soil, making plant growth impossible. A general rule of thumb is that organic matter with a carbon to nitrogen ratio (C/N) greater than 20:1 will cause nitrogen deficiency in plants unless more nitrogen is added. Fresh sawdust often has a C/N of 500:l.

There is considerable variability in physical and chemical properties of oak sawdust taken from different sources. Sawdust decomposes very slowly when left in undisturbed piles. In a recent survey of sawdust samples taken from typical" mills in the state, some piles as old as 15 years still had temperatures above 100° F which indicates that the material is still decomposing. Moisture content generally increased from about 30% in fresh dust to 60-70% in dust over 5 years old. Fresh dust is acidic, with a pH of about 4.5 but pH gradually rises to near neutral with aging. C/N generally decreases with age, fresh dust being 350:1 to 450:1 and materials over 5 years old generally ranging from 150:l to 250:1. While one old sample had a C/N of 30:1, some samples from piles20+ years old had ratios similar to those expected in piles 2 or 3 years old. Much of this variation appears to be related to the method of storage. Piles that are moved around age more quickly than those that are left undisturbed.

Effect of Oak Sawdust on Plant Growth

Results of a greenhouse study with tomatoes grown in equal parts of sawdust and sand indicated that if sufficient

Sawdust shows promise for horticultural applications including container growing media and soil amendments. It is important for the sawdust to display certain chemical properties to avoid stunting of plants. Sawdust materials with a carbon to nitrogen ratio of 100:1 or less and moisture content greater than 70% are best suited for horticultural uses. Proper aging, composting and additions of nitrogen can help achieve the proper levels.

nitrogen is added, oak sawdust can be used directly as a plant growing medium. In general, the samples with the lowest carbon to nitrogen ratios and the highest initial moisture contents (determined immediately after sample collection) grew the largest plants. However, even in fresh sawdust, growth of some plants was acceptable after an initial lag period. Three of the 10 sawdust samples performed better than the pine bark mixture used for comparison. Age was not a good indicator of the suitability for use as a plant growing medium. The two samples in which plant growth was poorest were estimated to be 16 and 25 years old. These two samples were also taken from deepest in the piles.

Another study evaluated the effects of oak sawdust used as a mulch or a soil amendment on plant growth in the field. A three-inch layer (4.5 ft) of fresh or aged (9-yr-old) sawdust was applied to 3 x 6 foot plots. In some plots, the dust was left as a mulch and in others it was tilled to a depth of 4 inches. Sawdust-treated and sawdust-free control plots received 0(N), 0.1(L) or 0.5(H) pounds of nitrogen applied as ammonium nitrate. Five 14-inch-tall forsythia plants were planted in each of the 90 plots in the experiment. All plants were cut back to 8 inches in March of 1993, and height was measured during the growing season. Soil samples were collected at the end of the experiment and analyzed forpH, sodium (Na), organic matter (OM), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), nitrate (NO_3) and ammonia (NH_3).

Fresh and aged sawdust reduced plant growth by 40% and 31% respectively when incorporated without supplemental nitrogen (Figure 1). Growth was normal when the high rate of nitrogen was added to aged sawdust. However, growth was still reduced in fresh sawdust plots with added nitrogen. Reduced growth was evident by the first measurement in June and became more obvious throughout the season. Neither aged nor fresh dust had a significant effect on growth when applied as a mulch.

Effect of Sawdust on Soil Properties

As shown in Table 1, sawdust incorporation resulted in a significant increase in soil organic matter (OM). While control plots and those treated with sawdust mulch had OM contents averaging from 2.2% to 2.5%, plots with incorporated aged and fresh sawdust averaged 5.3%

Figure 1.

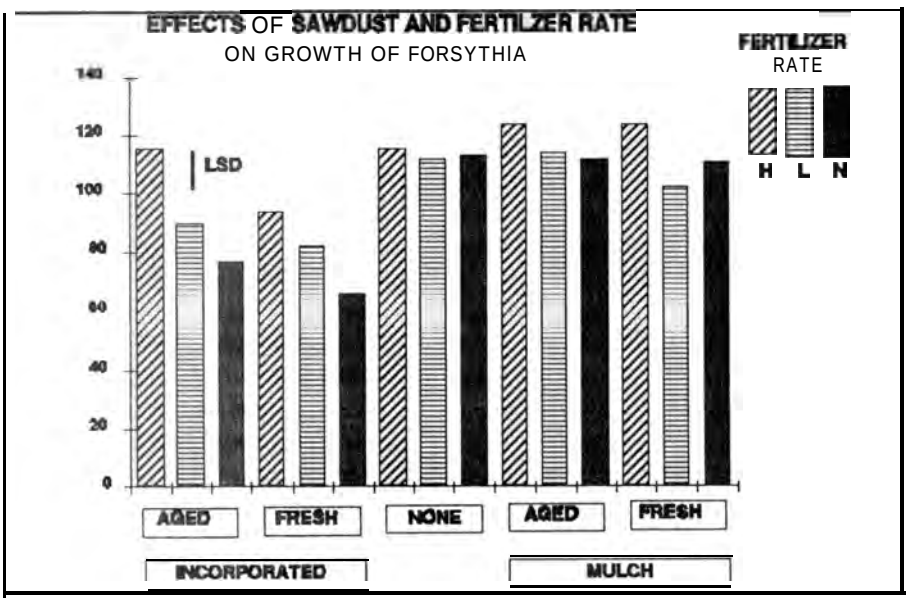

Table 1. Effects of sawdust application on soil characteristics.

Sawdust Treatment	pH	OM (%)	NO_3 (ppm)	NH_4 (ppm)	P (lb/A)	K
Aged Incorporated	5.8	5.3	0.7	5.4	71	355
Fresh Incorporated	6.1	4.3	0.6	4.9	67	381
None	6.0	2.2	1.9	6.9	82	351
Aged Mulch	5.9	2.5	1.3	6.1	84	356
Fresh Mulch	6.0	2.5	1.0	5.2	84	370
LSD (Least significant difference)	0.3	0.4	0.3	1.6	8.8	26

and 43.% respectaively. There was a notable improvement in the structure and workability of the soil in sawdust-incorporated plots. Nitrogen treatment had no effect on soil organic matter content.

Fresh and aged sawdust significantly reduced soil nitrate content even when used as a mulch and reduced phosphorus when incorporated. While plots receiving the high application of ammonium nitrate had significantly lower pH (more acidic) than control plots (5.5 vs 6.2, averaged over sawdust treatments), neither sawdust material had a significant influence on pH one year after incorporation. Plots with fresh sawdust incorporated had approximately 30 pounds per acre more potassium than those in other treatments. This might be because plants grew much less in these plots and therefore removed less potassium from the soil.

Composting

Current research is evaluating the feasibility of composting sawdust with poultry manure to overcome the problems associated with nitrogen deficiency. The results to date indicate that poultry manure is an excellent source of both nitrogen and microorganisms required for decomposition. Within 2 days of mixing, temperatures in a typical pile rise to 160 F because of bacterial action. Fungal organisms soon colonize the piles, maintaining a temperature of 120° to 140° for the following 6 weeks. Moisture in the pile should be maintained at 60-70% by adding water during periodic turning. After 90 days of composting, there is no trace of manure and the sawdust is dark brown with a humus-like odor. Composting sawdust eliminates the problem of nitrogen immobilization, allowing the material to be used as a soil amendment or potting soil component without supplemental nitrogen.

Recommendations

1. Based on greenhouse tests, sawdust materials with a C/N ratio less than 100:1 and a moisture content greater than 70% are best suited for horticultural uses.

2. Age is not a good indicator for predicting horticultural usefulness of a sawdust material. Storage in large, undisturbed piles slows the decomposition process considerably.

3. Samples of sawdust should be sent to a soil testing laboratory to determine C/N and content of P and K prior to use as a soil amendment.

4. Nitrogen deficiencies can result when sawdust is soil-incorporated prior to growing a crop. Supplemental nitrogen at a rate of 1400 pounds per acre did overcome the inhibition caused by aged sawdust. However, fertilization with such high nitrogen rates may lead to problems with water quality. It is important to note that sawdust-induced nitrogen deficiency is temporary. Some of the nitrogen immobilized during the first year is released in the soil as the microbes die and decompose. For this reason, sawdust should be incorporated with sufficient nitrogen

added to promote decomposition one or two seasons before the crop is grown.

5. The quantity of nitrogen to add can be estimated based on the amount required to reduce the C/N ratio to 20:1. For example, a sawdust with a C/N of 250 and containing 0.1% N (on a fresh weight basis) would contain about 25% carbon (0.1 x 250) or 500 pounds of carbon per ton. This material would therefore require about 25 pounds of actual nitrogen (500/20) per ton to reduce it's C/N to 20. A one inch layer of this sawdust is roughly equivalent to 50 tons per acre and would therefore require about 1200 pounds of N per acre. To avoid the possibility of runoff or leaching of nitrates, the nitrogen can be applied in several applications to a cover crop planted in the amended soil.

6. Composting with poultry manure shows promise as a method for improving the performance of aged sawdust used as a soil amendment or as a component of a container growing medium. Maintain the moisture content of the compost pile between 60 and 70% and the temperature between 120° and 150° F by turning and adding water frequently.

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Mention of trade names is solely to identify materials used and does not imply endorsement by the Missouri Department of Conservation. Discussion of pesticides in this paper is not a recommendation of their use and does not imply that uses discussed here are registered.

Results and recommendations presented in this paper are preliminary but represent our best analysis at the present time. Please use this information with care.